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Review

Anthropometry of hand in sex determination of dismembered remains - A review of literature

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ABSTRACT

Sex determination is an important and one of the foremost criteria in establishing the identity of an individual. Identification of dismembered/severed human remains that are frequently found in cases of mass disasters and criminal mutilation is a challenging task for the medicolegal experts. The paper presents a review of anthropometric studies conducted on hand with regard to identification of the deceased from dismembered remains. The review further discusses the anthropometric landmarks, techniques, methods, reliability and accuracy and the overall significance of hand anthropometry in personal identification. This review is an attempt to discuss the sexual dimorphism exhibited by the anthropometry of the hand that can assist forensic experts in the identification of amputated/dismembered remains.

1. Introduction

Personal identification refers to the determination of individuality of a person living or dead based on certain characteristics. Identification is required in living individuals, recently dead persons, decomposing and mutilated bodies, and skeletal and fragmentary remains. Amongst the various parameters of identification, determination of sex is an important and one of the foremost criteria in establishing the identity of an individual. Determination of sex is often considered as one of the simplest task in forensic analysis, as the external and internal genitalia can directly suggest the sex of an individual. The issue of sex differentiation however, is complicated in cases of intersex, bodies in advanced state of putrefaction, mutilated, fragmentary and skeletonised remains.

Studies in the past have reported a fair possibility of determining sex from skeletal remains and different body parts. The personal identification from extremities become increasingly important in cases of mass disasters, where there is a likelihood of recovering feet and hands separated from the body.[1] Accurate sexing of the remains primarily narrows down the pool of possible victim matches. Besides, sex determination is vital in further investigation of age and stature of the remains owing to the differences in age of epiphyseal fusion, and formulae for stature estimation in males and females. Accurate sex determination thus, provides some valuable evidences to a forensic scientist with regard to identification of remains.

This review attempts to discuss the sexual dimorphism exhibited by the anthropometry of the hand that can assist forensic experts in identification of amputated/dismembered remains.

2. Anthropology/anthropometry

Methods of biological anthropology are most commonly employed for personal identification despite of the modern techniques being available. Forensic anthropology is a branch of biological/physical anthropology primarily concerned with the postmortem identification of human remains in a medicolegal context. Two most commonly employed methods in forensic anthropology are the metric (Anthropometry) and morphological (Anthroposcopy) assessment of the living and skeletal remains. Anthropometry is the science that deals with the measurements of the size, weight and proportion of the human body and skeleton.[2,3] Anthropometry as a technique to take measurements on the

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human body, cadaver as well as on skeletal remains has been widely utilized in issues relating the identification of an individual.

Subjective and objective criteria have been developed for sex determination. Subjective sex determination is based on morphological features, while objective sex determination is based on metric analysis that includes various measurements and indices. Standards of morphological and morphometric sex differentiation differ with the population involved. The general adult male to female ratio is considered to be about 100 to 92 i.e. the female measurements are 92% of the male measurements.[2]

3. Hand morphology and landmarks[4]

Hands are specialized appendages at the distal end of the upper limbs that act as chief tactile apparatus. They are designed for grasping and precision movements for skilled works. Fingers represent the distal most region of the hand.[5] The fingers are denoted with the standard anthropological formula where 1 is the thumb, 2 the index finger, 3 the middle finger, 4 the ring finger and 5 the small finger, hence the digits are named as 1D, 2D, 3D, 4D and 5D respectively.

Flexures (joint lines) are the major markings found in the vicinity of synovial joints that are produced by adhesions of the skin to sub-adjacent deep fascia. The flexure lines commonly crease the skin across the flexor surfaces of the wrist, palm and digits and are the sites of folding of the skin during movement. These flexures are useful landmarks for measurements from the hand. Landmarks used for estimation of hand length and handbreadth include Interstylion, Dactylion, Metacarpal radiale, and Metacarpal ulnare. Interstylion is the middle point of the line connecting the point stylion radiale (the most distal point on the styloid process of the radius) and stylion ulnare (the most distal point on the styloid process of ulna). Dactylion is the most distal point on the tip of the third finger of the hand. Metacarpal radiale is the point projecting most medially on the head of the 2nd metacarpal when the hand is stretched whereas metacarpal ulnare, is the point projecting most laterally from the head of the 5th metacarpal.[6] Hand length is measured as the distance between the mid-point of inter-styloid line and dactylion, handbreadth as the distance between metacarpal radiale and metacarpal ulnare. Palm length is the distance between the mid-point of distal transverse crease of the wrist and the most proximal flexion crease of the middle finger. Finger lengths are measured as the distance between proximal flexion creases of the finger and the tip of that finger. Various landmarks and measurements on the hand are depicted in Fig. 1.

4. Significance of hand in identification

An individual hand when recovered and brought for examination, can provide valuable information about the age, sex, and stature of the person. Wrist and hand contain forty-five separate distinguishable centres of ossification. The appearance and fusion of these centres provide an excellent assessment of biological development of a growing individual. As per Mckern, complete union of epiphysis for metacarpals and phalanges in males occur between 14 and 19 years and in females between 13 and 17 years.[7] Besides estimation of age based on the ossification of bones of the hand, researchers have attempted to determine sex from the small bones of the hand.[8–13] The width of the phalanx and the total finger width of the index finger demonstrate statistically significant age and sex characteristics. Males have a significantly larger width of the phalanx, total finger width and soft tissue index than females in all age groups.[14] Various measurements of the phalanges have been studied for sex differentiation.[8,9] Musgrave and Harneja provided the first regression formulae to aid in the estimation of the stature

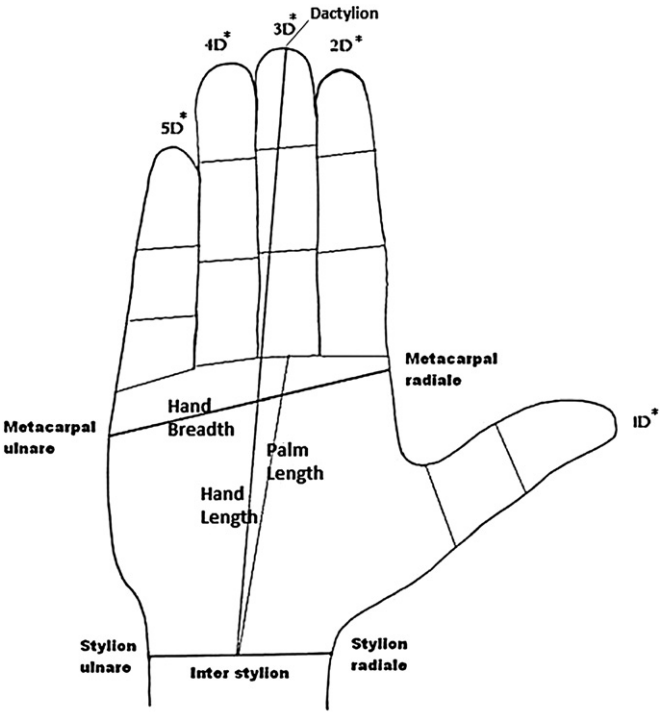

Fig. 1. Landmarks and measurements on the hand.

from the length of metacarpals. Since then a number of studies have estimated stature from the small bones of the hand.[15,16] Besides, hand measurements have shown significant correlation with fetal growth and have been employed in estimation of gestational age of a fetus.[17,18] Anthropometry of the hand is used to estimate the stature of an individual by regression analysis. Different hand measurements have been used to estimate stature in different age groups and populations.[19–23]

5. Sexual dimorphism exhibited by the anthropometry of the hand

The term 'sexual dimorphism' refers to any variations that manifests at the morphologic or nuclear level. Sexual dimorphism is obvious because of the differential development of internal and external genitalia as well as extragenital features such as body size, appendages and specific cellular components.[24] Anthropometry of hand and its different parameters that are valuable in sex determination of dismembered remains is presented in Fig. 2.

5.1. Hand and palm dimensions

Agnihotri et al reported male–female differences in hand dimensions among students in Mauritius.[25] The reliability of sex determination from soft tissue measurements of hand is established recently. Kanchan and Rastogi studied the sexual dimorphism of various hand dimensions and for the hand and palm indices derived from the hand dimensions, among North and South Indian population using statistical considerations.[26] The hand index was derived by using the formula: Hand Index = (Hand breadth/Hand length) × 100, while the palm index was derived using the formula: Palm Index = (Hand breadth/Palm length) × 100. Kanchan and Rastogi examined the utility of palm dimensions and palm

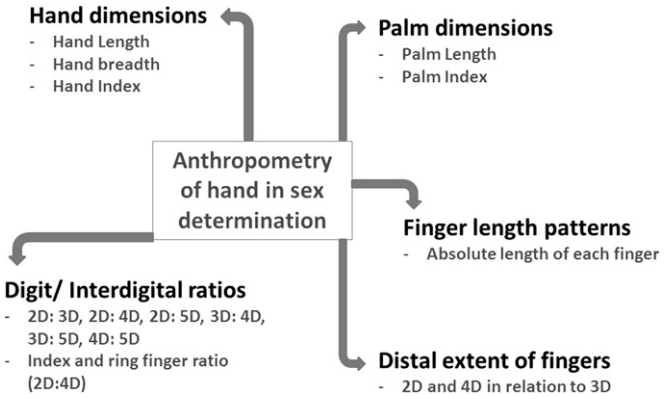

Fig. 2. Sexual dimorphism exhibited by the anthropometry of the hand.

index as a sex determinant for the first time.[26] Krishan et al studied the sexual dimorphism of hand dimensions in a North Indian population.[27] The studies confirm that sex can be established from hand and palm dimensions with a reasonable accuracy. Kanchan and Rastogi reported hand breadth to be the most reliable sex discriminator. Hand index and palm index remained poor indicators of sex.[26] Similar observations were made by Krishan et al[27] in a study done on Rajput population from Northern India.

5.2. Finger length patterns

Fingers can help ascertain the identity of an individual. Morphological sex differences in the absolute length of fingers have been demonstrated in various studies, male fingers being longer as compared to females.[28] The length of middle finger shows the maximum sexual dimorphism when compared to other fingers.[29] Sex difference in the length of ring finger is found to be larger as compared to length of index finger.[30] Significant male–female differences have also been found in lengths of thumb and little finger. The male thumb appears shorter as compared to female thumb, when the length of the thumb is measured in relation to the proximal phalanx of the index finger. Similarly the length of the little finger is less than 3/4th of the lengths of the middle finger in females i.e. females have a shorter little finger as compared to males.[31]

5.3. Distal extent of fingers

The fingers differ in their distal extent among males and females. In the mid-1950s, Rösler collected a massive sample of hand outline drawings. With regard to the distal finger-extent pattern, Rösler differentiated radial (longer index than ring finger), ulnar (reversed pattern), and intermediate hand types. The hand types reflect higher (more female-typical), lower (more male-typical), and intermediate digit ratio respectively.[32]

Sexual dimorphism is evident in the distal extent of the index and the ring finger. Relative to the middle finger, the index finger in males extends less far distally than females. Thus the difference between the distal extent of index and ring finger in relation to middle finger is more in males. The females have a smaller difference between distal extent of index and ring fingers i.e. both index and the ring finger tips in relation to middle finger, appear to be equal and at the same level in females. It is argued that the principle source of such a difference lies in the distal extent of index finger and not in the distal extent of the ring finger.[29] Findings of George suggest that ring finger in males is generally longer in terms of extent when compared to the index finger, while a reverse of the same is observed in females.[33]

5.4. Digit/interdigital ratios

Apart from the sexual dimorphism in the extent and length of the fingers, sex differences have been documented from various possible ratios between different finger lengths (interdigital ratios). The sex difference in these ratios is independent of the body size, as the ratios are not significantly related to height and age in either sex.[30] Sexual dimorphism is most marked for second to fourth digit ratio (2D: 4D ratio), followed by second to fifth (2D: 5D) and third to fourth (3D: 4D) digit ratio.[34] Manning observed marked sexual dimorphism for second to third (2D: 3D) ratio.[35] It has been suggested that the ratio between the index (2D) and the ring finger (4D) is a sexually dimorphic trait that differs in different population groups. The digit ratios are unique in a way that they are established even before birth, while other sexually dimorphic variables are fixed after puberty. The task of sex differentiation otherwise is more difficult when the remains are prepubertal as the characteristic traits that indicate sex do not appear until after puberty.

5.5. Index and ring finger ratio

In females, index and ring finger tend to be almost equal in length whereas in males ring finger tends to be much longer. Thus, the index and ring finger ratio becomes a significant parameter for determining sex.[36] The ratio between the index and ring finger length is known as 2D: 4D ratio. Studies by Lippa, McFadden, and Manning et al. have demonstrated sexual dimorphism in 2D: 4D ratio.[30,34,35,37] Lower digit ratios are considered “masculine” and higher ratios as “feminine”. Manning reports that the length of the index finger is generally about 96 percent of the length of the ring finger i.e. the average 2D: 4D ratios for males are 0.96.[38] Besides sexual dimorphism, second to fourth digit ratio shows significant ethnic and population differences.[39–41] Voracek and Loibl have published a much detailed scientometric analysis and bibliography of research on digit ratio during the last decade.[42] Index and ring finger ratio has been found to be a useful sex determinant in South Indian population.[36,43,44] The index and ring finger ratio as a sexually dimorphic trait is established early in life and remains fairly stable postnatal; it does not change with age and growth in a population group.[45,46]

6. Reliability and accuracy in anthropometry

Precision and accuracy are of utmost importance in anthropometry. While conducting any forensic study based on anthropometry, the reproducibility of the measurement must be taken into consideration. Anthropometry requires a lot of practice and experience before one can actually begin conducting studies and making standards based upon quantitative data. The results of the studies conducted without calculating personal error/technical error, are thus subject to major error.[47] While collecting data, the anthropometric instruments like anthropometer and sliding caliper must be checked regularly for their accuracy and reliability. The most common errors in anthropometry are positioning of the body or bones, reading measurements and recording. These errors are termed as personal error and technical error of measurement respectively. In order to minimize these errors, internationally recognized standard procedures should be used for recording measurements.[48] One can calculate technical error of measurement by using different methods devised by anthropometrists and other experts, and calculate the error in a quantitative manner.[49,50]

7. Conclusion

Advent of DNA technology has simplified the issue of sex determination in medicolegal investigations to a great extent. DNA analysis however, may not be a reasonable option in all cases of identification of commingled remains/cases of mass disasters. Moreover, DNA technology has its limitations with regard to skilled manpower, time and financial issues involved, especially in developing countries, and in cases when DNA analyses cannot be performed. Various techniques in forensic anthropology are still most commonly employed for identification of human remains, and somatometry of hand can be a useful adjunct in establishing the sex of dismembered/amputated remains.

Conflict of interest

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